Risk Factors of Massive Bleeding After Percutaneous Nephrolithotomy and its Management

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OBJECTIVE: We studied the risk factors for massive bleeding after a percutaneous nephrolithotomy (PCNL) and propose an algorithm of management.

MATERIALS AND METHODS: Medical charts of 450 subjects who underwent PCNL from 1993 to 2001 were reviewed. Risk factors including age, gender, concurrent medical illness, previous renal surgery, operative time, intraoperative blood transfusion, and hydronephrosis were examined for their relationship to bleeding.

RESULTS: Massive bleeding occurred in 12 subjects (2.67%) among whom 11 required embolization and 1 open surgery. The angiographic diagnoses revealed an arteriovenous fistula in 6 subjects, pseudoaneurysm in 3, arteriovenous fistula combined with pseudoaneurysm in 2, and lacerated renal vessels in 1. In 11 patients who underwent embolization, 2 required another session of the procedure. The failure of embolization in 1 patient necessitated surgical flank exploration. Pyuria, prolonged operative time, and increased intraoperative blood transfusions were statistically significant factors related to massive bleeding.

CONCLUSIONS: Angiography with embolization is an effective modality for massive bleeding after PCNL. According to our study, subjects with urinary tract infection may be at greater risk for bleeding. Avoiding excessive manipulation may shorten the operative time, which is a preventive measure for hemorrhage. Increased intraoperative blood transfusions may be an early warning sign of massive bleeding after the procedure. **(JTUA 14:65-71, 2003)**

Key words: percutaneous nephrolithotomy, angiography, embolization, arteriovenous fistula, pesudoaneurysm, pyuria.

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is less invasive than open procedures and has gained wide application for calculi of the upper urinary tract. Hemorrhage is 1 of the common complications and may occur at any point during the clinical course beginning with the nephrostomy puncture [1,2]. Most cases of hemorrhage can be treated conservatively, but some require arterial embolization through angiography or even open surgery [3]. We report on the incidence, treatment, and risk factors of these serious vascular injuries at our institution.

MATERIALS AND METHODS

Between July 1993 and May 2001, the charts of 450 PCNLs performed at our hospital were retrospectively reviewed. All patients had normal coagulation studies, and no patient had sepsis. A percutaneous nephrolithotomy was performed by the 2-stage procedure [4]. An access tract was created from the skin into the collecting system under fluoroscopic and sonographic guidance. The tract was dilated with a dilator to a size appropriate to accept the balloon catheter. The angiographic balloon (30 Fr., 8 cm in length) was in-

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flated to dilate the tract between the skin and renal pelvis. A percutaneous nephrolithotomy was performed the following day in the standard fashion according to techniques described previously [5].

The 450 subjects were categorized into 2 groups based on whether massive bleeding occurred after the procedure. Massive bleeding was defined as a decrease in hemoglobin of more than 2 g/dl after more than 4 units of blood had been transfused. The group with massive bleeding required arterial embolization or open surgery after conservative treatment failure. Age, gender, concurrent medical illness, operative time, previous renal surgery, intraoperative blood transfusion, and hydronephrosis were examined for a relationship to massive bleeding by a logistic procedure (SAS version 8.2).

RESULTS

Twelve patients (2.67%) were described in whom massive bleeding following percutaneous nephrolithotomy was uncontrolled by the usual methods and who were treated by embolization or open surgery (Table 1). Among the 12 patients requiring aggressive measures, there were 10 males and 2 females, aged 46-72 (mean, 61) years. The side of the nephrostomy puncture was on the left in 5 and on the right in 7. The indication for the procedure was staghorn stone in 6, multiple renal calculi in 4, and ureteropelvic junction stone in 2. Of the 12 patients, 7 had no history of previous renal surgery, 3 had undergone extracorporeal shock wave lithotripsy, 4 had a history of previous PCNL, and 1 had undergone an open nephrolithotomy previously. The mean operative time for PCNL was 130 (range, 60-200) minutes. The mean intraoperative blood transfusion was 1270 (range, 0-5000) ml. The clinical manifestations of massive hemorrhage included persistent bloody nephrostomy drainage in 8, acute urinary retention in 9, flank pain in 6, fever in 3, and acute renal failure in 1.

Renal arteriography showed an arteriovenous fistula in 6 patients, a pseudoaneurysm in 3, an arterio-

Table 1. Demographic data of 12 patients with massive bleeding after PCNL

		No. of patients (%)
Indications for PCNL	Ureteropelvic junction stone	2 (17)
	Staghorn stone	6 (50)
	Multiple renal calculi	4 (33)
Gender	Male	10 (83)
	Female	2 (17)
Co-morbidities	Diabetes	3 (25)
	Hypertension	2 (17)
	Renal insufficiency	2 (17)
	Liver function impairment	4 (33)
	Acute pyelonephritis	5 (42)
Previous renal surgery	No	7 (58)
	ESWL	3 (25)
	PCNL	4 (33)
	Open nephrolithotomy	1 (8)
Side of puncture	Left	5 (42)
	Right	7 (58)
Symptoms/signs	Persistent bloody nephrostomy drainage	8 (67)
	Acute urine retention	9 (75)
	Flank pain	6 (50)
	Fever	3 (25)
	Acute renal failure	1 (8)
Timing of massive bleeding	Immediately after needle puncture	1 (8)
	Within 24 h after PCNL	3 (25)
	Within 2 to 14 days after PCNL	6 (50)
	More than 14 days after PCNL	2 (17)
Angiographic findings	Arteriovenous fistula	6 (50)
	Pseudoaneurysm	3 (25)
	Arteriovenous fistula with pseudoaneurysm	2 (17)
	Vessel laceration	1 (8)

venous fistula with pseudoaneurysm in 2, and lacerated renal vessels in 1 (Figs. 1, 2). Treatment consisted of highly selective embolization with coils. One session was successful to stop the hemorrhage in 9 cases, while 2 cases required 2 sessions. An arteriovenous fistula could not be embolized in 1 case because of a technical problem. The failure of embolization necessitated a surgical flank exploration.

Demographic and clinical characteristics of the 450 subjects in each group are summarized in Table 2. Statistical analysis was performed using logistic regression to assess the statistical significance of all variables between the 2 groups. The level of significance was $p = 0.05$. There was no statistically significant difference in terms of age, gender, previous renal surgery, or current medical illness. Furthermore, the degree of hydronephrosis between the 2 groups was similar. However, the rate of pyuria, operative time, and intraoperative blood transfusion were statistically significant factors that differed between the 2 groups. The rate of pyuria, prolonged operative time, and increased intraoperative blood transfusion were statistically associated with significant bleeding.

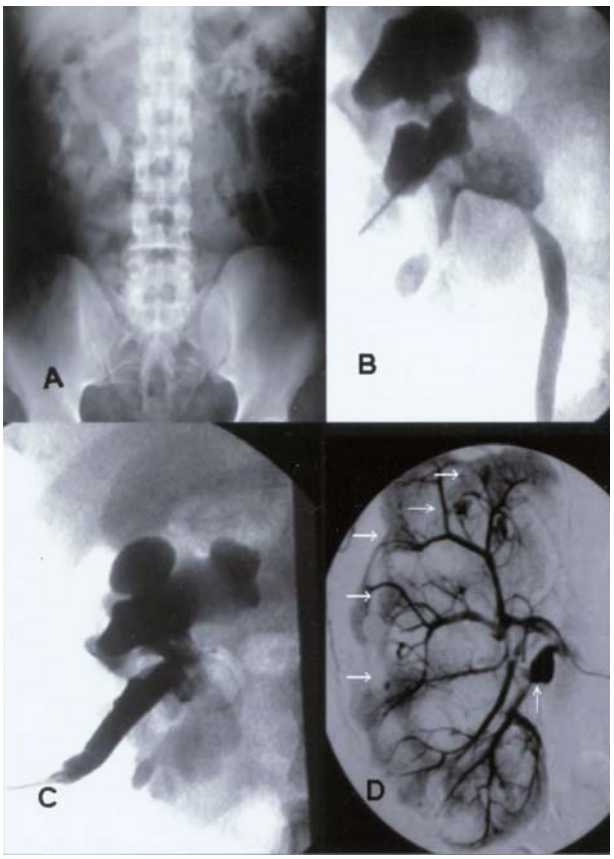

Fig. 1 (A-C) Patient with renal calculi and TB kidney who underwent middle pole tract creation. (D) Multiple aneurysms which occurred immediately after needle puncture (arrow).

DISCUSSION

Blood loss is 1 of the common complications of percutaneous nephrolithotomy with 1% to 11% requiring a blood transfusion. Bleeding may result from traumatized renal parenchyma or injury to the perinephric vessels [6]. Massive bleeding can occur during needle puncture, tract dilatation, intraoperative instrument manipulation, or in the postoperative period [2]. Renal vessel damage with subsequent formation of arteriovenous fistulas or pseudoaneurysms is a well-known source of bleeding after kidney operations. Arteriovenous fistulas and pseudoaneurysms of the renal arteries are formed by a high-pressure leak from a lacerated artery. The leak is transmitted through the tract into a lower resistance system, such as a vein or a connective tissue space [7]. There have been reports of bleeding attributable to arteriovenous fistulas or pseudoaneurysms as late as 13 weeks after a percutaneous nephrolithotomy [8]. In our study, 50% (6/12) of massive bleeding occurred in the early postoperative period (2 to 14 days after PCNL), and arteriovenous fistula formation as a late complication 40 days after PCNL was noted in 1 patient.

The first step in managing excessive blood loss is to monitor the vital signs of a patient (Fig. 3). A

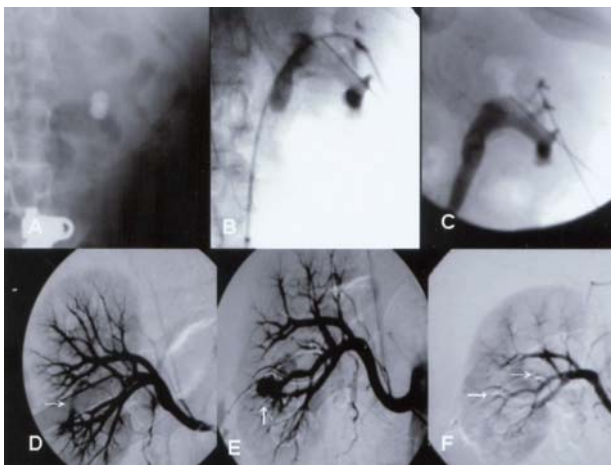

Fig. 2 (A-C) Even with selective calyx puncture, vessel injury still occurred. (D) Angiography showing no bleeder focus before the balloon is deflated (arrow). (E) Active bleeding identified after the balloon is deflated (arrow). (F) Bleeding having ceased after successful embolization (arrow).

Table 2. Demographic and clinical characteristics of patients in the 2 groups with and without massive bleeding

	Massive bleeding	No massive bleeding	p Value
No. of patients	12	438	
Female/Male	2/10	131/307	0.0769
Avg. age ± SD (yr)	61 ± 6	56 ± 8	0.2309
Diabetes (%)	3 (25%)	87 (20%)	0.2309
Hypertension (%)	2 (17%)	57 (13%)	0.1390
Renal insufficiency (%) [a]	2 (17%)	92 (21%)	0.5646
Liver function impairment (%) [b]	4 (33%)	109 (25%)	0.5757
Pyuria (%) [c]	10 (83%)	311 (71%)	0.0018
Acute pyelonephritis (%)	5 (42%)	136 (31%)	0.9541
Previous renal surgery (%)	5 (42%)	140 (32%)	0.1915
Avg. operative time ± SD (min)	130±35	91 ± 40	0.0143
Avg. intraoperative blood transfusion ± SD (ml)	1270 ±677	370 ±120	0.0007
Hydronephrosis			
No (%)	4 (33%)	136 (31%)	0.1017
Mild (%)	2 (17%)	91 (21%)	0.2356
Moderate (%)	3 (25%)	128 (29%)	0.0766

[a]Renal in sufficiency was defined as Cr>2mg/dl. [b]Liver function impairment was defined as GPT>40U/L.
[c]Pyuria was defined as WBC>1+/HP.

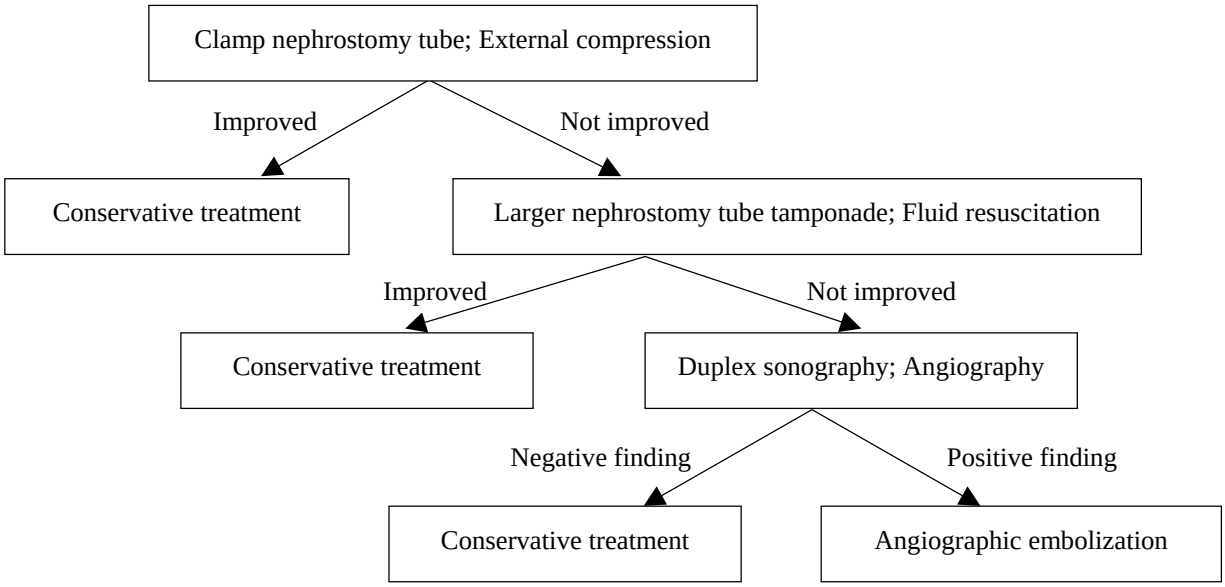

Fig. 3 Algorithm of management of massive bleeding after PCNL

nephrostomy tube should be placed in the tract and clamped for 4-8 hours, and an external compression dressing applied. A larger nephrostomy tube will tamponade the tract better. If the bleeding from the nephrostomy tube continues or gross hematuria with acute urine retention occurs, a blood transfusion plus fluid resuscitation and Foley catheterization with urinary bladder irrigation should be administered. Hydration and intravenous administration of mannitol in hemodynamically stable patients can lead to rapid forced diuresis and swelling of the kidney within the capsule, which may enhance tract tamponade.

In case of failure of these maneuvers, we recommend further evaluation with diagnostic imaging tools including color duplex sonography or angiography. Vascular lesions can be treated with angiographic embolization. Hyperselective embolization in our series was effective in 11 of 12 cases. One patient with massive bleeding suffered from acute renal failure after PCNL. The hyperselective embolization and fluid resuscitation permitted the serum creatinine to return to its preoperative level. The reported success rate of this

technique in the literature is over 80% [2]. Embolization compromises blood flow to a portion of the kidney because of embolic occlusion of the intrarenal arterial branches. Partial renal ischemia and subsequent renal infarction are disadvantages of embolization. A possible complication of renal infarction involves a change in renal function. Kernohan et al. [9] reported a case of complete embolization of the renal artery which resulted in loss of the kidney. Selective embolization was not successful in that case due to an abnormal arterial anatomy which made it impossible to embolize the feeding artery selectively.

Minimizing the number of needle punctures and selecting the correct puncture site are important in preventing excessive blood loss. Although the number of needle punctures was not recorded in our study, it would seem logical that the likelihood of damaging renal vessels would be greater with a higher number of needle punctures. A thorough understanding of renal vascular anatomy is essential for determining a correct puncture site [10]. Because the posterior calyces are generally oriented so that their long axis points to a relatively avascular area, a posterolateral puncture directed at a posterior calyx would be expected to traverse through this relatively avascular zone [11]. The upper poles of both kidneys are usually more posterior and more medial than the lower poles; therefore, access through an upper posterior calyx is closer to the long axis of the kidney and allows easier and smoother passage of rigid instruments toward the lower pole rather than the other way around [12].

Patients with arteriosclerosis of the renal artery branches accelerated by aging, hypertension, or diabetes are presumably at a higher risk for hemorrhage [13]. Arteriosclerosis may impair the ability of the self-healing properties of the arterial wall because of the loss of its normal muscle and elastic layers. Hemostatic factors are also important in the formation of pseudoaneurysms and fistulas. Bleeding tendency is frequently noted in patients with uremia, and liver cirrhosis and those under anticoagulant agent treatment. Furthermore, the presence of an underlying infection may delay the formation of firm blood clots at the vascular puncture site. Kidneys that have had retroperitoneal inflammation from renal infection and are fixed in the retroperitoneum are especially at risk of parenchymal trauma during percutaneous intrarenal surgery [14]. Kessaris et al. reviewed 2200 percutaneous renal procedures performed at their institution, and reported that age, gender, medical illness, stone burden, number of renal punctures, and procedure duration were not risk factors for bleeding [2]. However, our study shows that the proportion of pyuria was significantly higher without massive bleeding among all 450 patients. Before proceeding with percutaneous calculus manipulation, the patient's catheterized or voided midstream urine specimen should be cultured if pyuria (WBC > 1+/HP) is present. According to our experience, E. coli is the most common pathogen cultured from patients with pyuria. Subjects with underlying urinary tract infection may have been at greater risk for bleeding in our series. The operative time was significantly prolonged in the group with massive bleeding. This phenomenon implies that excessive manipulation with instruments during the operation should be avoided. Moreover, a greater amount of blood was transfused during the operation in the group with massive bleeding. Increased intraoperative blood transfusion may be an early warning sign of massive bleeding after the procedure.

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